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The Thermal Radiation from Sun Spots. Observations made at Daramona, Streete, co. Westmeath. By W. E. Wilson.

In 1894 March Dr. Johnstone Stoney kindly communicated to the Royal Society some observations of mine on the above subject.* In this preliminary note a full description is given of the instruments and of the method of observations. It is therefore unnecessary to again describe them, but merely to mention that a large image of the Sun is formed by means of a heliostat and projected on to a screen in the observatory. Behind this screen, and standing on a pier of concrete, is placed a Boys radio-micrometer. A small pinhole in the screen admits radiant heat into the radio-micrometer. By placing any part of the solar image over the pinhole we can measure the relative radiation of this part. Two long rods and handles come into the observatory from the heliostat, and by turning these any desired part of the solar image can be accurately placed over the pinhole aperture. The driving clock of the heliostat then keeps it in this position while an observation is being made. The standard to which all the values of radiation from spots &c. are compared is the value on an arbitrary scale of the deflection of the radio-micrometer when the centre of the solar image is allowed to fall into the pinhole aperture in the screen.

In taking an observation, the zero position of the spot of light on the scale when the pinhole is closed is first noted, and its value entered in column Z. The umbra of a spot is then placed, by means of the slow-motion handles, on the pinhole, which is then opened. The amount of deflection produced is then entered in column U. The image is then moved so that a portion near the spot, but at the same distance from the limb, falls into the pinhole. The deflection from this is entered in column N. And finally the solar image is placed centrally, and the radiation from the centre of the disc is entered in column C.

When the values in column Z are subtracted from those in U, N, and C, we get comparative values of the radiation from the umbra, the neighbourhood, and the centre of the Sun.

In a former paper † it has been shown that the deflections of the radio-micrometer are, at any rate up to 20°, strictly proportional to the amount of radiant energy falling on the instrument. We are therefore authorised in taking these values as

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* *Proceedings of the Royal Society*, vol. lv.

† "Effective Temperature of the Sun," Wilson and Gray, *Phil. Trans.* vol. clxxxv. A.

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equal to the amount of radiant energy reaching us from the different parts of the Sun. It has long been known that the radiation from the limb of the Sun is much less than from the centre, and that this is probably caused by a layer of what we may call smoke, which lies over the photosphere. It seemed to be an interesting point to investigate whether the radiation from a Sun spot falls off when near the limb in the same manner as a point in the photosphere, and since the commencement of these observations this point has been investigated. In the preliminary note published in the spring of 1894 I showed from observations then recorded that the radiation from the umbra of spots does *not* suffer absorption when near the limb, in the same manner as a point on the photosphere. These observations have been continued during the summer and autumn of last year and confirm the earlier ones.

In 1874 and 1875 Langley,* by means of a thermo-pile and galvanometer, measured the radiation from Sun spots. The mean value that he gives for the umbral radiation is 0·54. Instead of taking the radiation from a point in the centre of the disc as his standard, Langley took two points on the photosphere, the first situated between the spot and the centre, and the second between the spot and the limb. The mean of these two photospheric readings he then used as a divisor for the umbral reading. Langley seems to have been unable to observe that the radiation from the umbra of a spot is nearly constant for different distances from the centre of the disc. He says, "The decrement of heat as we approach the limb is, though not exactly, yet so very nearly, in the same ratio for photosphere and spots, that no correction is needed on this account." An inspection of the values of $\frac{U}{N}$ in Table I. clearly shows that the radiation from the umbra of a spot, as its distance from the centre increases, becomes closer to the value of the radiation from the neighbouring photosphere. Whereas the values of $\frac{U}{C}$ remain nearly constant. As Langley's observations were taken near a solar minimum year and mine at a solar maximum, it is just possible that the radiation from spots may vary during this period. Future observations taken throughout a complete sun-spot cycle may show that the spots are formed during the solar minimum at a lower level, and thus suffer more absorption near this limb than they do during a solar maximum.

I have collected the monthly means of my observations from August 1893 to Nov. 1894, and plotted out the values of $\frac{U}{C}$ in the following curve:—

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* *Monthly Notices*, vol. xxxvii. No. 1.

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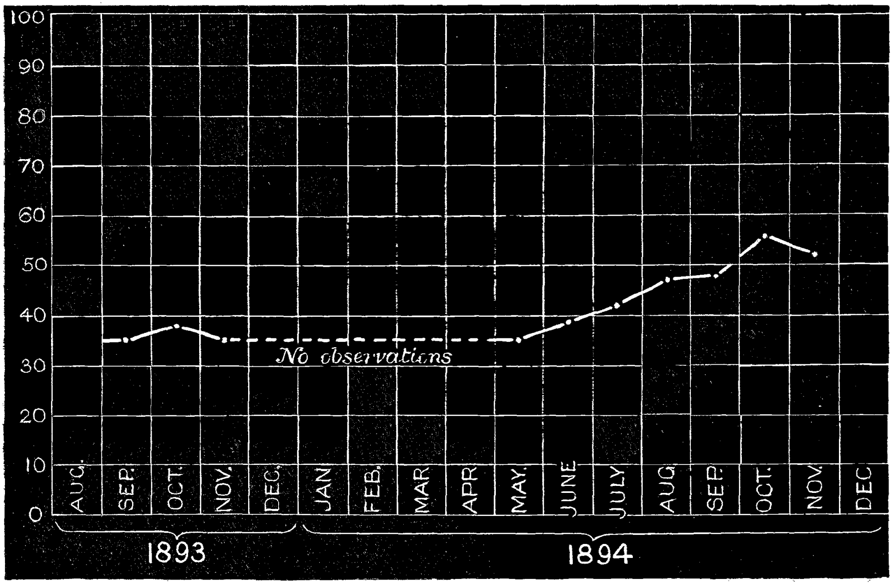

Fig. 1.—Radiation from an equal area of the photosphere at the centre of the disc = 100.

It will be seen that the umbral radiation is considerably lower during 1893, and since May 1894 the values of $\frac{U}{C}$ have increased from 0·35 to over 0·50.

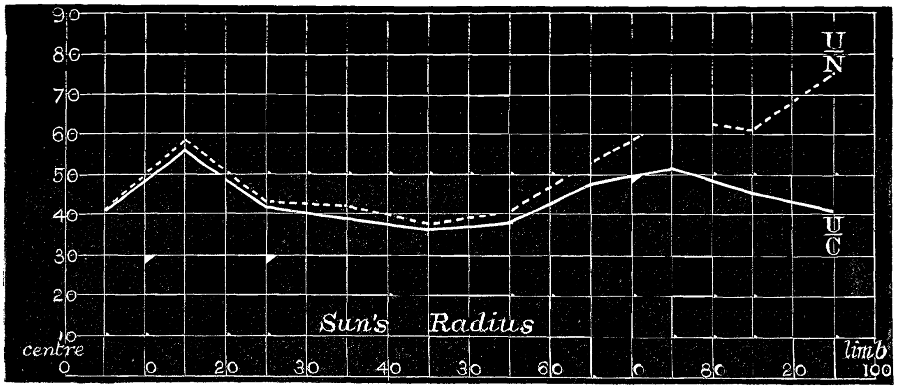

Fig. 2.—Radiation from an equal area of the photosphere at the centre of the disc = 100.

In fig. 2 I have collected the values of $\frac{U}{C}$ and $\frac{U}{N}$ according to distance along the Sun's radius. The continuous curve gives the values of $\frac{U}{C}$, while the dotted one gives those of $\frac{U}{N}$, and shows how the latter departs from the former as the limb is approached.

Since I published my first observations my attention has been drawn to a paper on this subject by Professor Frost, of

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Dartmouth College, U.S.A. He there points out the same fact as I have—that the light from umbra of spots does not suffer absorption when they are near the Sun's limb in the same manner as a point in the photosphere. He also records some observations in which he found the radiation from the umbra greater than that from the neighbouring photosphere when the spot was close to the limb. I have never been able to observe this. The greatest value for $\frac{\mathrm{U}}{\mathrm{N}}$ that I have recorded is 0·83.

In Table I. are given the ratios of the radiation from the umbra (U), the neighbouring photosphere (N), and the centre (C). In column D is given the distance of the spot from the Sun's centre, in hundredths of the radius. Where observations are bracketed together it signifies that it is the same spot that has been observed on different days. Unfortunately, in this climate we are very seldom able to observe a spot for many days in succession.

TABLE I.

Date.		$\frac{\mathrm{U}}{\mathrm{C}}$.	$\frac{\mathrm{U}}{\mathrm{N}}$.	D.	Remarks.
1893.					
Aug.	5	0·37	0·43	60	
	7	0·29	0·29	40	
	8	0·29	0·32	50	
	8	0·34	0·38	40	
	8	0·42	0·51	90	
	14	0·36	0·37	50	
	19	0·37	0·37	50	
Sept.	2	0·31	0·31	10	
	3	0·30	0·30	10	
	4	0·42	0·45	30	
	4	0·43	0·45	30	
	7	0·29	0·35	85	
Oct.	1	0·40	0·40	30	
	1	0·49	0·57	80	
	22	0·34	0·35	52	
	26	0·36	0·41	40	
	29	0·32	0·71	90	
	30	0·36	0·78	95	
	30	0·58	0·65	...	No real nucleus.
Nov.	8	0·36	0·80	97	
	9	0·34	0·85	92	

Date.	$\frac{U}{C}$.	$\frac{U}{N}$.	D.	Remarks.
1894.				
May 30	0·34	0·34	...	Spot A.
30	0·32	0·34	57	Spot B
31	0·33	0·34	45	Spot A.
31	0·39	0·40	42	Spot B.
June 6	0·38	0·54	85	
30	0·41	0·61	89	Spot A.
30	0·62	0·66	...	Spot B. No definite umbra.
July 1	0·43	0·76	97	Spot A. Spot B nearly filled up.
21	0·61	0·64	60	Sky hazy.
21	0·46	0·52	58	
30	0·42	0·47	65	
30	0·38	0·78	94	
30	0·39	0·67	92	
Aug. 6	0·49	0·51	41	
22	0·46	0·70	96	
Sept. 8	0·42	0·58	74	
9	0·47	0·51	61	
10	0·43	0·45	41	
13	0·47	0·47	...	Spot nearly central.
14	0·45	0·50	53	Same spot as observed on 8th, 9th, 10th, 13th.
29	0·58	0·66	83	
30	0·55	0·61	67	
Oct. 4	0·60	0·66	72	
4	0·56	0·59	19	
4	0·55	0·64	84	
7	0·54	0·64	...	Clouds.
19	0·53	0·83	96	
Nov. 5	0·51	0·52	57	
5	0·61	0·61	5	
5	0·49	0·71	84	
8	0·42	0·83	90	
8	0·54	0·69	72	
8	0·58	0·60	40	
30	0·48	0·80	94	
30	0·50	0·78	83	

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A Negative Optical Proof of the Absence of Seas in Mars.

By H. Dennis Taylor.

When occupied in reading a highly interesting article on the physical configuration of *Mars* in *Astronomy and Astrophysics* an idea suddenly struck me which seemed to me a valuable one —viz. that if there exist seas, or even water-covered spaces of moderate size, within the tropical regions of *Mars*, then we should expect to see a minute but brilliant reflection of the Sun in such water spaces whenever, by the diurnal rotation of the planet, they were brought into the proper angle to send us a solar reflection. I at once entered into a few simple calculations which satisfied me that the apparent brightness of this solar reflection, analogous to a reflection of the Sun from a thermometer bulb, would at least compare on fairly equal terms with the brightness of a 1st magnitude star. I then drafted a paper on the subject and submitted it to the March Council meeting of this Society, along with a note in which I said I could scarcely believe that its matter was entirely novel, and that the idea had not occurred to anybody before. At the same time I was not aware of any books on astronomy in which the important bearing of this question upon the physical state of *Mars* was even alluded to. Since then, however, one of the referees to whom my paper was submitted has kindly referred me to the memoir of Schiaparelli on *Mars* and to a paper dealing with this very question by Professor Phillips, of York, which, it seems, was published first in the *Proceedings of the Royal Society*, vol. xii. 1863. So that the claim for priority rests, I believe, with Professor Phillips. But until the other day I was quite ignorant of this, and the fact that the very same idea should afterwards recur to me, living in the same town, seems to suggest that there is something in ideas akin to certain epidemics. In the course of discussing the nature of the markings upon *Mars*, Professor Phillips wrote: "A positive proof of ocean on the disk of *Mars* would be afforded by the star-like image of the Sun reflected from the quiet surface or the more diffused light thrown back from the waves; but nothing of this sort has been placed on record." In a note he also wrote: "The quiet image here alluded to would not exceed $\frac{1}{20}$ of a second of angle at the opposition, if no allowance be made for irradiation." He then concludes by assuming it doubtful whether this star-like image would be visible except perhaps in very large instruments. But he enters into no calculation as to the apparent *brightness* of this "artificial star" as viewed from the Earth and as compared with other real stars.

Then Professor Schiaparelli, in his beautiful and elaborate memoir on *Mars* during the opposition of 1877, took up the subject again as being of the very highest importance. While expressing himself as very doubtful as to whether the darker